BASIN AND CRATER EJECTA CONTRIBUTIONS TO THE SOUTH POLE-AITKEN BASIN (SPA) REGOLITH: POSITIVE IMPLICATIONS FOR ROBOTIC SURFACE SAMPLES.

N. E. Petro[1] and B. L. Jolliff[2], [1]NASA\GSFC, Code 698, Greenbelt, MD, 20771, [2]Washington University (email: Noah.E.Petro@nasa.gov).

Introduction: The ability of impacts of all sizes to laterally transport ejected material across the lunar surface is well-documented both in lunar samples [1-4] and in remote sensing data [5-7]. The need to quantify the amount of lateral transport has lead to several models to estimate the scale of this effect. Such models have been used to assess the origin of components at the Apollo sites [8-10] or to predict what might be sampled by robotic landers [11-13].

Here we continue to examine the regolith inside the South Pole-Aitken Basin (SPA) and specifically assess the contribution to the SPA regolith by smaller craters within the basin. Specifically we asses the effects of four larger craters within SPA, Bose, Bhabha, Stoney, and Bellinsgauzen all located within the mafic enhancement in the center of SPA (Figure 1). The region around these craters is of interest as it is a possible landing and sample return site for the proposed MoonRise mission [14-17]. Additionally, understanding the provenance of components in the SPA regolith is important for interpreting remotely sensed data of the basin interior [18-20].

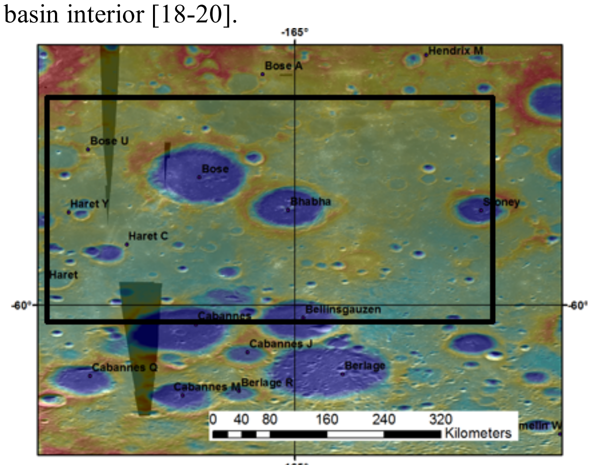

Figure 1. Study region in central SPA around Bose (d=91km), Bhabha (d=64km), Stoney (d=45km), and Bellinsgauzen (d=63km). Base image is LOLA topography draped over Clementine 750nm mosaic. Warm colors indicate higher topography within central SPA, while blues are lower regions. Region is located in deepest portions of the basin. The black box outlines the region investigated in detail below.

Modeling Lateral Transport: The two primary approaches for estimating the total amount of lateral transport focus either on taking a statistical average of how the cratering process moves material across the surface [e.g., 21, 22] or specifically modeling the effects of individual craters [e.g., 11, 12]. For the most part, these studies have treated ejected material as a single component when in reality the lateral transport process introduces two components to a regolith, a "foreign" component comprised of material from the impact site and an impact melt component [13, 23-25]. Here we focus mainly on treating ejecta as a single component, following the work of Petro and Pieters [26], we do address the melt component in ejecta.

Here, we assess the contribution from various sources, specifically basins, distant post-basin craters, and nearby, large craters.

Basin Contributions: The ejecta contribution by basins to the center of SPA has previously been assessed in detail [12, 27]. These previous assessments both concluded that the contributions of post-SPA basins is relatively minor, the regolith in the center of SPA is predicted to contain roughly 20-50% non-SPA-derived material. This calculated contribution by basins comprises both impact-melt and "foreign" material. The central portion of SPA (Fig. 1) is estimated to receive some of the smallest accumulations of basin ejecta across the Moon [26].

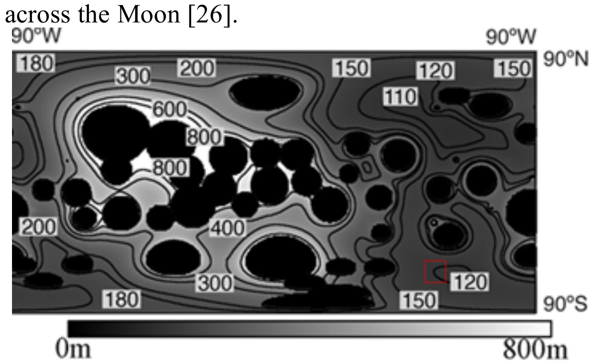

Figure 2. Lunar-wide map of cumulative basin ejecta, centered on the eastern limb [26]. Region of interest (Fig. 1) is outlined in red. This example utilized the Housen et al. [28] ejecta scaling equation.

Distal Crater Contributions: In assessing the effects of numerous craters it becomes nearly impossible to account for all craters, so some combination of approaches is necessary. Fortunately the Apollo 16 samples provide clues as to what degree post-basin formation cratering laterally moved material [1, 9]. The Apollo 16 soils (<1mm size fraction) contain ~6% mare basalt fragments, likely introduced to the site following the formation of the Imbrium basin [2]. Knowing that the nearest mare basalts are 220km away and that the full compositional range of likely sources is no further than 1100km, we can constrain the likely source region for the source of the basalts (Figure 3).

Based on the distribution of mare within the likely source region, we can estimate that the total contribution of post-basin formation material to be at least ~15% of the Apollo 16 regolith. This insight in the lateral transport process is important as we can readily gauge the origin of a small component of the regolith for any location on the Moon.

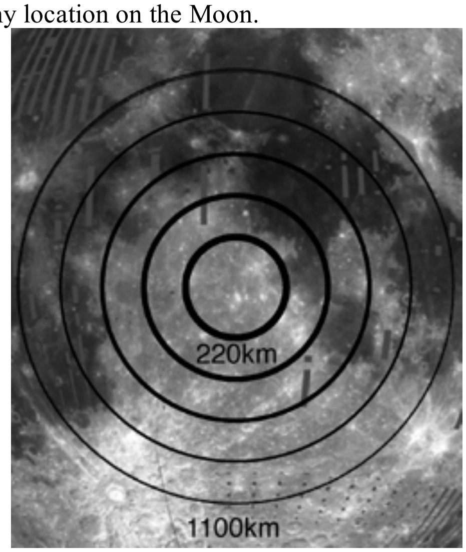

Figure 3. Apollo 16 centered view of the lunar nearside, showing possible sources for the mare component at Apollo 16. The increasing rings at greater distances illustrate larger source regions for the basalts. Ultimately, if the ~6% mare basalt component originated between 220 and 1100 km, then ~9% would have likely come from highland locations.

Specific Nearby Crater Contribution: While the above approach is useful for gauging the general effects of impact craters, it is important to assess the effects of specific craters individually. For a small region in SPA, the cumulative effects the four largest craters as well as several other smaller craters (Fig. 1) are considered at a distributed set of points across the surface, similar to the basin analysis discussed above. The cumulative amount of ejecta deposited is nearly equivalent to the amount of ejecta introduced by basins (Fig. 2); however, because of the smaller size of these craters (between 45 and 91 km), the total fraction of impact melt in their respective ejecta deposits is likely to be much smaller (as much as 80%) than what is expected for the larger impact basins [13]. Additionally, because these events post-date all but the youngest of basins [29], the contributions from these craters will be concentrated in the uppermost regolith [13, 17], and will not have been remixed as the older basin ejecta is expected to have been. We can also expect that the ages of the non-melted material will reflect the ages of the target rock, and for much of this region, that target is SPA impact-melt. These large craters likely sampled the upper 6-9km of the crust, and much of the ejecta will be from the uppermost portions of that crust. Therefore we expect that much of the ejecta from these craters is dominated by SPA derived impact-melt.

Conclusions: Based on the relatively minor expected contribution of ejecta from basins (20-50%), the small contribution of distal crater ejecta (~15%), and the contribution of primary crustal material (in this case SPA impact melt) by local, large craters, we can confidently predict that the non-mare [17] regoliths in central SPA will be dominated by SPA-derived impact-melt. A well selected landing site, outside clear mare and cryptomare deposits [30], for a sample return mission will likely sample an impressive mixture of material, dominated by SPA impact melt.

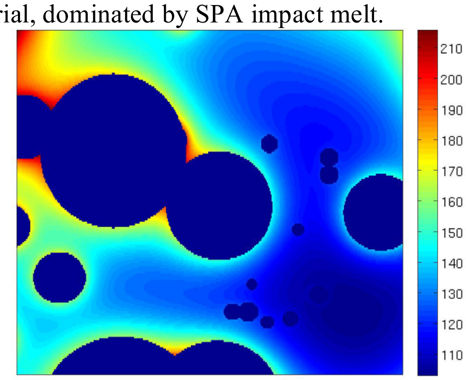

Figure 4. Estimated ejecta accumulation (in meters) by regional craters (area outlined in Fig. 1). Bose is the large crater at upper left, Stoney is at right. As in Fig. 2, ejecta model is based on Housen et al. [28].

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